Saturn, 2003–'04

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A report of the Saturn, Uranus & Neptune Section. Director: M. Foulkes

During 2003–'04, with Saturn at perihelion, the rings were fully open upon the south face allowing excellent views of the southern hemisphere and up to 12 belts. Since 2002–'03 there had been an obvious darkening of the S. Polar Region, though the existing lighter area in the centre of the S. Polar Cap had become more conspicuous. Spot activity was noted over a wide range of latitudes from the N. edge of the S. Polar Cap to the southern Equatorial Zone. White spots in the South Tropical Zone and South Equatorial Belt Zone continued from the previous apparition and showed similar drift-rates. The southern Equatorial Zone showed the same slow drift-rate that has been apparent since 1994–'95, and dark spots on the SEB(N) also exhibited a period slower than System I. The occultation of the star SAO 78867 by the rings and globe was witnessed by several observers in the UK and USA.

Figure 1. 2003 Sep 29, 03:57UT, ω_1= 103°, ω_3= 204°, 279mm SCT, ATK-1HS camera at f/31, *D. A. Peach*. STropZ white spot near the CM; SEBZ white spot following. Note ring details and SSPC.

General

The period of the 2003–'04 apparition was defined by solar conjunctions on 2003 Jun 24 and 2004 Jul 8. Shortly after the earlier date, and before BAA observations commenced, Saturn arrived at perihelion on Jul 26. The planet came to opposition in Gemini on Dec 31 with the rings virtually fully open, and at declination +22°. At opposition the value of D_e equalled –25°.5, varying only from –24°.8 to –26°.3 during the period of observation from 2003 Aug 20 (Gray) till 2004 Jun 5 (Yunoki). Dr R. D. Bowen submitted a fine series of 48 visual observations, and Dr W. P. Sheehan was able to make a fine drawing with the Lick refractor (previously published in the *Journal*).[1] New imaging contributors were numerous. Most of those in Table 1 sent images, but the number of visual observers and visual observations fell, especially in the area of intensity estimates (Table 2), even if their data were in excellent accord.

An Interim Report by David Graham (then Section Director) & Damian Peach[1] mainly discussed the continuing STropZ and SEBZ white spot activity, noting that spot activity was observed from the SPC N. edge all the way down to the equator. (The present report supersedes the interim one in terms of drift-rates.) The SEBZ activity was at the highest level for the current presentation of the southern hemisphere. The apparition also saw dark spot and festoon activity at the SEB N. edge. The SPR had darkened since the previous opposition. Up to 12 belts were detectable in the best images.

Cooperation was maintained with Drs G. Orton (of the *Cassini* mission) and A. Sanchez–Lavega (International Outer Planets Watch, IOPW). Interest was heightened by the occultation of SAO 78867 by the rings.[2] A final report was produced by the ALPO,[3] and online image databases were maintained by the IOPW,[4] ALPO Japan (JALPON)[5] and the UAI.[6] *Cassini* would arrive in orbit at Saturn on 2004 Jul 1,[7] sending back numerous detailed images, and it is interesting to compare its viewpoint with groundbased observation: see Figure 4. The HST would also secure several images.[8]

Sanchez–Lavega has discussed the immediate pre-*Cassini* HST and IOPW data to derive drift-rates for various latitudes.[9] Several of our observers did infrared imaging; methane band work was

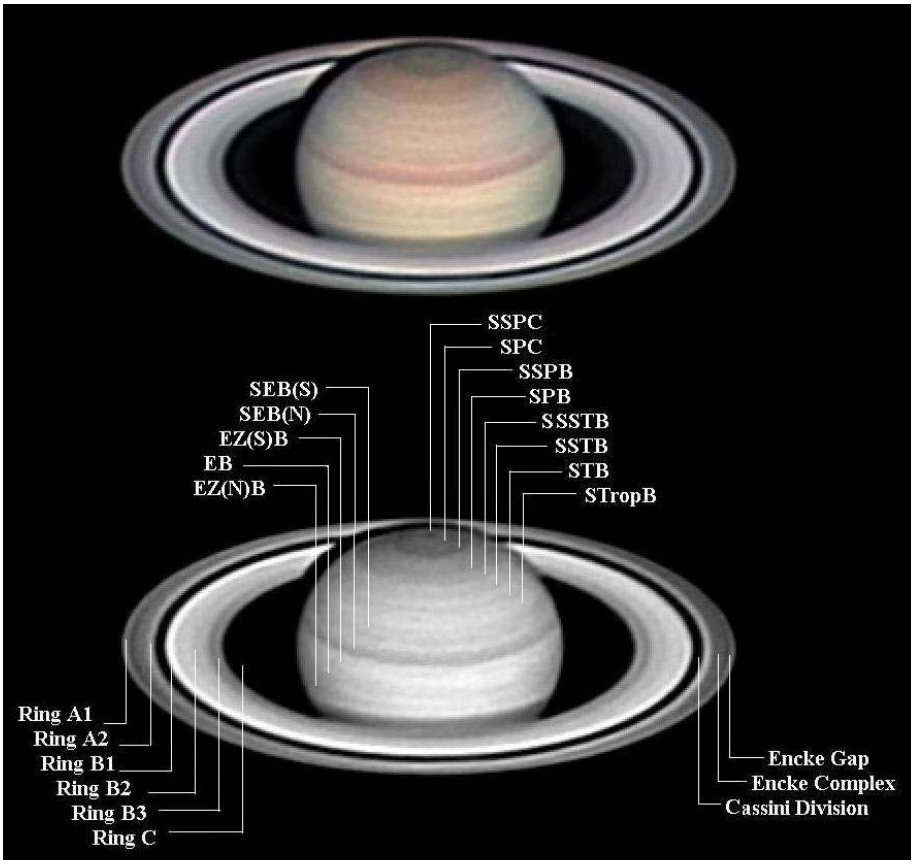

Figure 2. 2003 Oct 19, 11:14UT, ω_1= 326°, ω_3= 107°, 356mm SCT, f/27, ST5 CCD camera, *E. A. Grafton*. White spot activity in SEBZ, activity in EZ(S), and dark spot *p.* CM in STropZ. Tiny dark spot N. of SSPB *p.* the CM. Many belts and ring details. General nomenclature is given in the monochrome copy of the image (below).

done by Akutsu and Cidadao, and Akutsu and Pellier secured ultraviolet images. Orton was able to secure remarkable near-infra-red images with the NASA 3-metre telescope on Mauna Kea, which can be viewed online.[4]

This account is in continuation of our report for 2002–'03.[10]

The globe

General

As in other recent apparitions, the best images revealed no fewer than 12 belts, and Figure 2 has been labelled to illustrate belt and ring details.

Table 1. Observers

Observer	*Location(s)*	*Instrument(s)*
E. Africa	West Chester, OH, USA	203mm SCT
T. Akutsu	Tochigi, Japan	320mm refl.
N. D. Biver	Versailles, Paris, France	407mm refl.
R. D. Bowen	Wakefield, W. Yorks.	300mm refl.
N. D. Bryant	Glasgow	254mm SCT
C. L. Calia	Ridgefield, CT, USA	127mm OG, 203mm SCT
P. Casquinha	Palmela, Portugal	203mm refl.
R. Chavez	Powder Springs, GA, USA	203mm refl., 203mm SCT
A. Cidadão	Oeiras, Portugal	254mm SCT
J. A. Clark	Gravesend, Kent	203mm SCT
E. Colombo	Milan, Italy	152mm refl.
B. A. Colville	Cambray, Ontario, Canada	200mm MKT, 300mm SCT
J. Cooper	Wootton, Northants.	178mm Mak–Newt.
B. Daversin	Ludiver, France	600mm Cass.
T. Dobbins	Coshocton, Ohio, USA	356mm SCT
C. Fattinnanzi	Macerata, Italy	250mm refl.
M. Foulkes	Hatfield, Herts.	203mm SCT, 254mm refl.
(with P. Carter)	Tewin, Herts.	254mm SCT
E. A. Grafton	Houston, TX, USA	356mm SCT
D. L. Graham	Ripon, N. Yorks.	152mm MKT
D. Gray	Kirk Merrington, Co. Durham	415mm DK
J. P. Hatton	Mill Valley, CA, USA	235mm & 250mm SCT
A. W. Heath	Long Eaton, Notts.	203mm SCT, 254mm refl.
C. Hernandez	Miami, FL, USA	229mm MKT
T. Ikemura	Nagoya, Japan	310mm refl.
K. Johnson	Selsey, West Sussex	140mm MKT
T. Kumamori	Sakai City, Osaka, Japan	600mm Cass.
P. R. Lazarotti	Massa, Italy	252mm refl.
R. J. McKim	Upper Benefield, Northants.	410mm DK
F. J. Melillo	Holtsville, NY, USA	203mm SCT
C. E. Meredith	Manchester	203mm SCT, 215mm refl.
D. Miller	Barberton, OH, USA	254mm SCT
M. P. Mobberley	Bury St Edmunds, Suffolk	300mm SCT
E. Ng	Hong Kong, China	320mm refl.
D. Niechoy	Göttingen, Germany	203mm SCT
D. Novakovic	Yardley Gobion, Northants.	203mm refl.
T. Olivetti	Bangkok, Thailand	180mm MKT
G. Orton	Mauna Kea, Hawaii	3m NASA IRTF
P. W. Parish	Rainham, Kent	152mm OG
D. C. Parker	Miami, FL, USA	410mm refl.
D. A. Peach	Loudwater, Bucks.	235mm & 279mm SCT
C. E. Pellier	Bruz, France	178mm MKT &
(with G. Farroni)		356mm SCT
J. H. Phillips	Charleston, SC, USA	203mm & 229mm OGs
J. R. Sánchez	Córdoba, Spain	279mm SCT
W. P. Sheehan	Lick Obs., California, USA	36-in (0.91m) OG
R. Tatum	Richmond, VA, USA	254mm refl.
M. M. Taylor	Leicester	356mm SCT
D. B. V. Tyler	Flackwell Heath, Bucks.	152mm OG, 213mm refl.
K. Yunoki	Sakai City, Japan	200mm refl.

Abbreviations: SCT= Schmidt–Cassegrain; DK= Dall–Kirkham Cassegrain; MKT= Maksutov–Cassegrain; OG= Refractor ('Object Glass'). Observations by Daversin were communicated by Pellier.

Figure 3. 2003 Nov 7, 17:02UT, ω_1= 013°, ω_3= 230°, 310mm refl., Philips ToUcam Pro webcam, *T. Ikemura.* Tiny dark SSPC; SEB(S) dark spot imaged (near CM).

Global colours

The SPB and STB were obviously much fainter than the SEB(N) in red and green light (Figure 7) but nearly as dark as it in blue, pointing to a greater degree of redness. The SPR was lightest in red light, also indicating a warm tone. Visually Foulkes, Gray and McKim sometimes saw a brownish colour in the SPR (though this tint could not be detected with smaller apertures), SPB and also in the smaller, central SPC.

On the other hand the wide dark SSPB bordering the SPC was darkest in red light and faintest in blue, indicating a more bluish tone. Dobbins (Sep 17) also considered that his colour CCD work showed a blue-green tint to the SSPB, and Hernandez reported a greenish tint visually on Mar 29.

Dobbins (also Sep 17) found the high temperate latitudes (between STB and SPB, and therefore STeZ and SSTeZ) light bluish, and Gray (Dec 8) agreed, describing them a 'duck-egg-bluish-green'. Biver, Dec 23 (Figure 13) found the disk more greenish

Table 2. Visual intensity estimates, 2003–'04

Feature	*RB*	*MF*	*DGy*	*AH*	*RM*	*Ave.*	*No.*
SPC	5.4	4.9	4.8	–	5.4	5.1	119
SSPB	–	–	5.5	–	5.8	5.6	42
SPR	4.8	4.5	4.3	–	5.3	4.7	106
SPB	5.5	4.8	5.1	–	5.8	5.3	72
SSTeZ	–	–	3.2	–	4.3	3.8	47
SSTB	–	–	3.9	–	–	3.9	41
STeZ	3.9	2.9	2.6	3.5	3.3	3.2	139
STB	4.5	–	4.2	–	4.2	4.3	64
STropZ	3.6	2.7	2.7	2.6	3.2	3.0	138
SEB(S)	4.9	4.8	4.7	–	5.4	5.0	104
SEBZ	3.5	–	3.6	–	3.9	3.7	96
SEB(N)	5.4	4.9	5.7	4.5	5.6	5.2	138
EZ(S)	1.5	1.4	2.1	1.9	1.9	1.8	138
EB	2.7	3.0	3.3	2.5	3.4	3.0	112
EZ(N)	2.0	1.8	1.6	–	1.9	1.8	120
Ring A1	3.8	3.9	3.9	3.0	3.5	3.6	139
Encke's divn.	6.2	–	7.6	–	6.9	6.9	49
Encke complex	–	–	4.8	4.0	3.1	4.0	50
Ring A2	3.2	3.4	3.0	2.1	3.0	2.9	116
Cassini's divn.	10.0	10.0	9.1	9.6	10.0	9.7	137
Ring B1	1.0	1.0	1.2	1.0	1.1	1.1	138
Ring B2	2.3	3.0	2.4	1.5	2.4	2.3	133
Ring B3	–	3.7	3.8	-	2.9	3.5	52
Ring C	8.3	8.0	7.5	8.5	7.4	7.9	152
Ring C_m	6.2	7.7	4.4	8.5	5.3	6.4	135
ShRG	10.0	–	8.4	–	7.2	8.5	43
ShGR	10.0	10.0	–	10.0	10.0	10.0	88
Total used	963	368	1,038	80	259		2,708

Key to observers: RB, Bowen; MF, Foulkes; DGy, Gray; AH, Heath; RM, McKim.

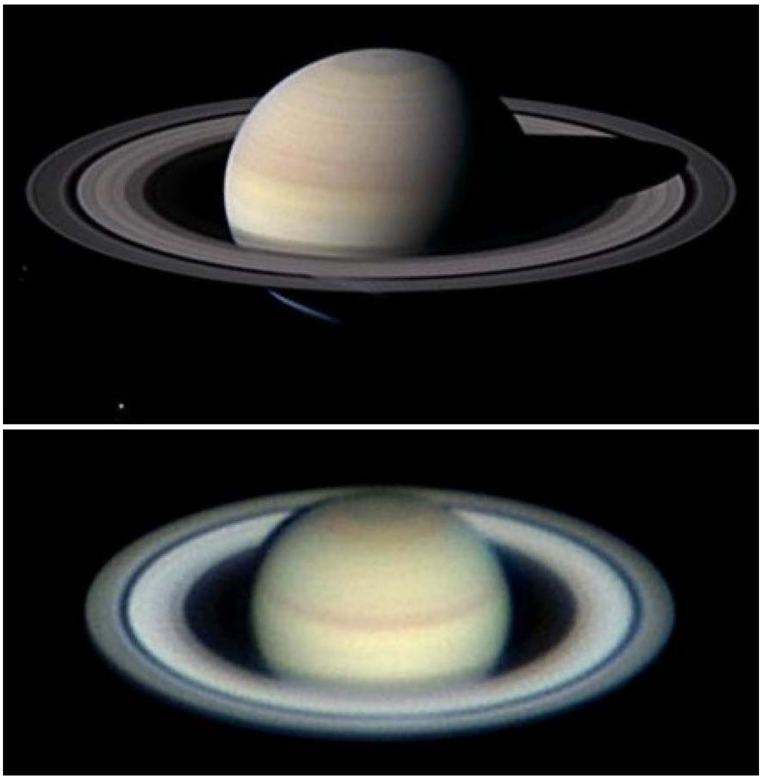

Figure 4. A *Cassini* image compared with a ground-based view on the same day. *Top:* 2003 Nov 9 08:54UTC (spacecraft event time): image taken with the narrow angle camera from 0.754 au. Note the blue tint of the sliver of visible N. hemisphere. Tethys is N*p*. the planet. *Bottom:* 2003 Nov 9, 04:04UT, ω_1= 166°, ω_3= 334°, 250mm refl., and Philips Vesta Pro webcam, *C. Fattinnanzi*.

south of the STB. Figure 7 shows that the STeZ and STropZ differed a little in brightness with wavelength, and does not contradict the foregoing. Others agreed that the STeZ was less yellow (and thus without a strong warm tint) than the conspicuously yellowish STropZ.

All agreed upon the usual strong reddish-brown tone of the SEB and the yellowish tint of the EZ(S): visually these were the regions of highest colour intensity. The EZ(N) was less yellow and looked whitish or grey, but its previous superior brightness had faded to a similar intensity to the EZ(S). The EZ(S) was quite dull in the ultraviolet images (Figure 15), at which wavelength the difference between N. and S. was greatest.

South Polar Region

Compared to 2002–'03, the SPR and the SPB had significantly darkened, returning to a more typical aspect. Compare Table 2's intensity data with 2002–'03.[10]

The SPC was a darker kernel within the SPR, and its edge – the wide SSPB – was darker still. At the centre of the SPC lay a tiny dark patch, which we have labelled the SSPC in this and other recent reports (see Figures 1–4, 7, 8 and 11). The SSPC corresponds with the 'polar vortex' observed by Cassini. This apparition Biver, Gray, McKim and Sheehan were unable to catch the tiny SSPC, but Bowen (Figure 17) and Hernandez resolved it several times. It was bordered by a light zone that had a better defined inner edge than in 2002–'03, especially in red light. The light zone was much more conspicuous, and it was readily seen visually.

High resolution images by Grafton (Oct 19 (Figure 2), Nov 5, Dec 7 and Jan 14) and Peach (Dec 15–16 (Figure 11)) each showed a tiny dark spot off the N. edge of the SSPB, at saturnicentric latitude −72°, best viewed in red light. Graham and Peach[1] considered the Dec 15–16 spot (λ_3= 302°) might be the same as that caught by the HST on Dec 5 (λ_3= 171°), but the longitude difference is much too great. It appears that there were several different features. Tiny spots were suspected upon other images but they were always doubtful, and at the limit of detection. SSPBn spots recorded by Grafton on Oct 19 (λ_3= 110°) and Dec 7 (λ_3= 128°) were very probably the same, and the same feature may have been caught by Ng on Dec 23, but one cannot be completely certain. Using HST images Sanchez–Lavega[9] found a period for this latitude close to System III.

The SSPB appeared completely circular, and showed no southern equivalent of the north polar 'hexagon', as *Cassini* would later image at extreme high resolution.[11]

North of the SPB lay a thin SSSTB, visible in the best images, and seen a few times by McKim visually. Under exceptional conditions on Dec 16 Peach imaged a very small light oval spot near λ_3= 340° in the SSSTeZ (near the CM in Figure 11).

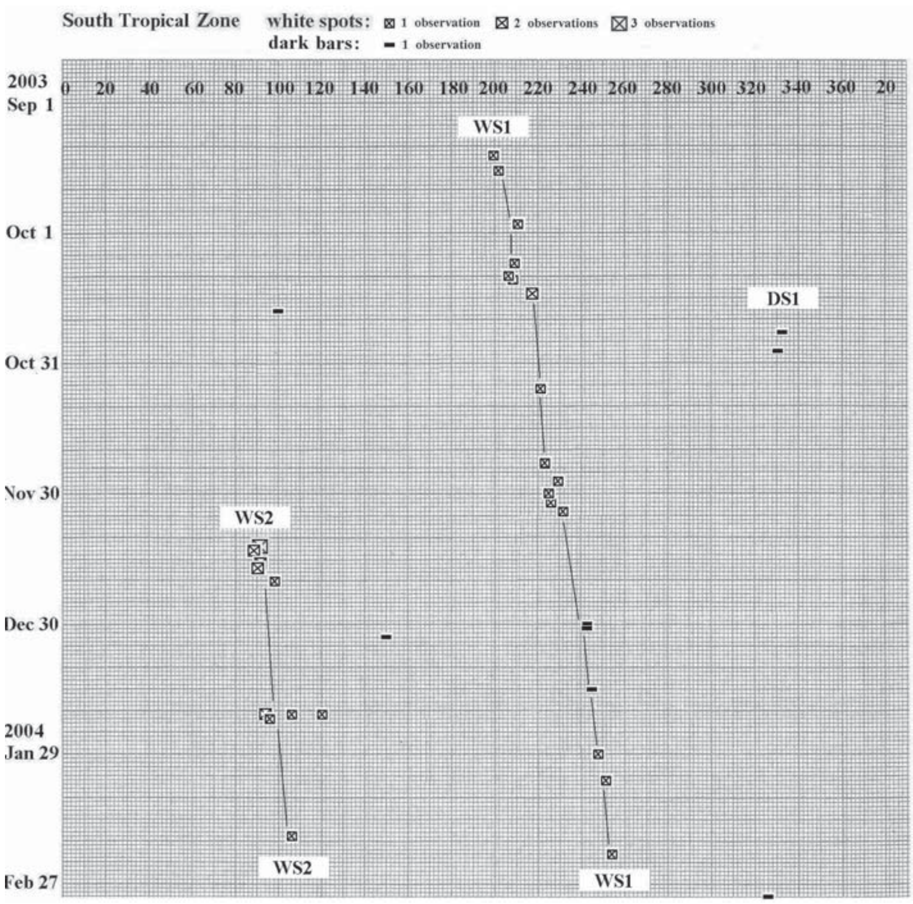

Figure 5. Drift-chart for the S. Tropical Zone, in System III longitudes. The features plotted were the centres of STropZ white spots (represented by crosses within squares) and dark bars (short horizontal lines). For multiple observations on one date, an average longitude has been plotted. *R. J. McKim.*

S. S. Temperate Belt and Zone

The SSTeZ was featureless, and the SSTB very thin and faint, paler than in 2002–'03 and now less conspicuous than the SSSTB.

South Temperate Zone

The STeZ exhibited a small, faint white oval at saturnicentric latitude –45° upon Grafton's images of Nov 4 (λ_3= 40°) and Nov 30 (λ_3= 192° (Figure 8)). No drift-rate can be inferred for there is an issue of continuity, the feature not being caught in excellent images by J. R. Sanchez under ω_3= 196° on Nov 28, nor in other good images between Nov 4 and 30. As recent and historical data show $\Delta\lambda_3$ for the STeZ to be close to zero, the Nov 4 and 30 features were different and short-lived.

Grafton found another very faint STeZ oval on Dec 7 near λ_3= 110°, and McKim recorded a light area in the STeZ near the f. limb on Dec 17 (Figure 12), close to the longitude of Grafton's spot ten days earlier and indicating a period close to System III.

South Temperate Belt

The STB was almost featureless, and darker than the SSSTB or SSTB.

South Tropical Zone

This was the site of continued white spot activity at saturnicentric latitude –37° during Sep 13 to Feb 20, according to the images of Casquinha, Fattinnanzi, Grafton, Hatton, Ikemura, Lazzarotti, Parker, Peach, Pellier, Sanchez and Yunoki.

The spots showed similar drift rates to 2002–'03[9,10] but were longer-lasting. The drift-chart (Figure 5) shows clustering of sightings several times along the tracks of WS1 (Figure 10) and WS2 (Figures 1 and 8), pointing to their being brighter at times and then fading to be missed upon intermediate images of those longitudes. The first observed spot (WS1) was very faint at first, but the second was immediately conspicuous. For example, WS1 is present but very faint upon Grafton's fine image of Nov 6. On Jan 20, Yunoki's image showed two more faint spots following WS2.

The longer-enduring WS1 was suspected of oscillating in longitude during Sep–Oct as the variations from the linear best-fit line were greater than the likely errors in the observations. During a gap in visibility of WS1 in Dec–Jan, there were some sightings of tiny E–W elongated dark bars in the STropZ at precisely the extrapolated longitudes: features never previously resolved by amateurs. Specifically these were imaged by Daversin and Pellier (barely) on Dec

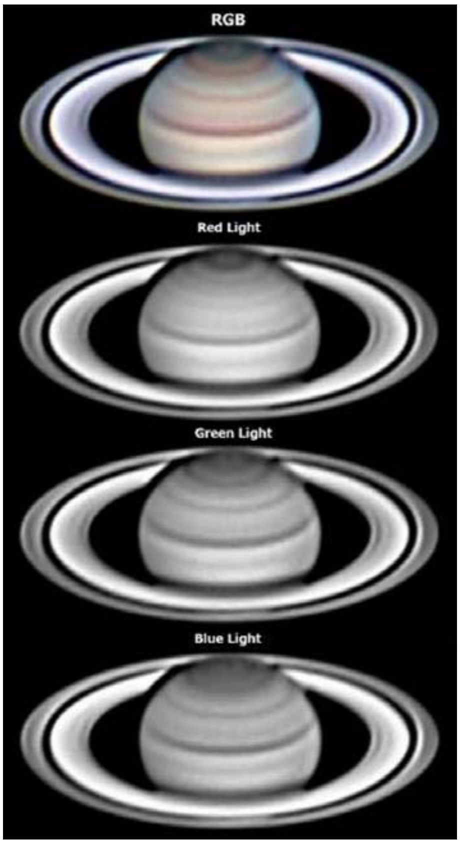

Figure 7. 2003 Nov 28, 00:16UT, ω_1= 236°, ω_3= 132°, 279mm SCT, ATK-1HS camera at f/31, *D. A. Peach*. From top to bottom, RGB, R, G and B images. Note the wavelength-dependence of the intensities of the global features, particularly near the pole.

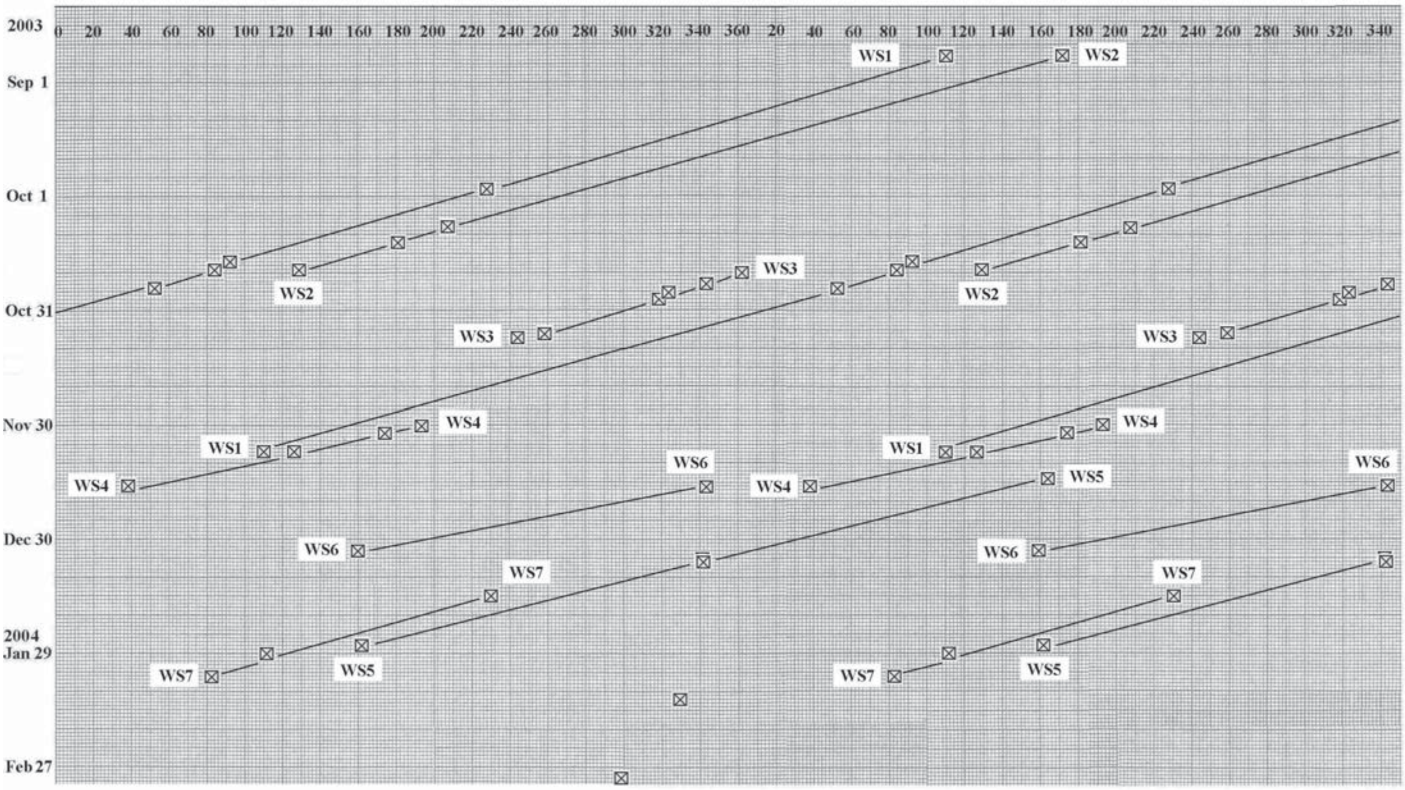

Figure 6. Drift-chart for the S. Equatorial Belt Zone white spots, in System III longitudes. The centres of SEBZ white spots have been plotted as crosses within squares (all representing single observations). The tracks of some spots have been plotted twice for clarity. *R. J. McKim.*

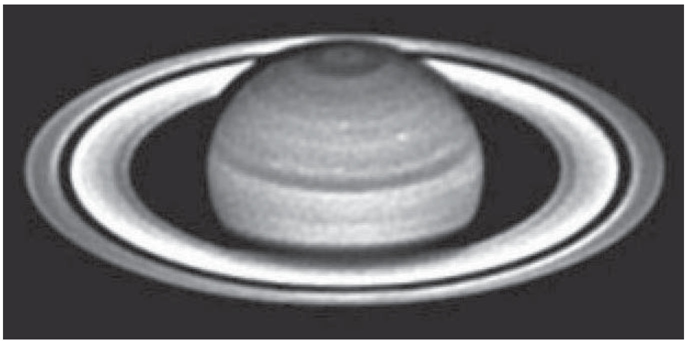

Figure 8. 2003 Nov 30, 07:26UT, ω_1= 017°, ω_3= 196°, 356mm SCT, ST5C CCD camera at f/27, *E. A. Grafton*. High contrast monochrome image to illustrate white spots in the STeZ, STropZ and SEBZ. Note the SSPC and many fine ring details.

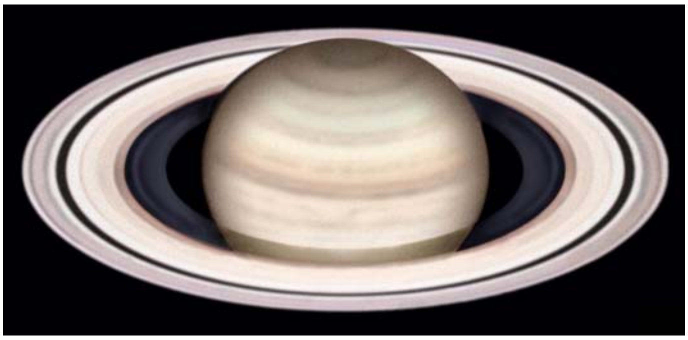

Figure 9. 2003 Dec 8, 02:30UT, ω_1= 118°, ω_3= 037°, 415mm DK Cass., ×348, drawn by *D. Gray*. Impressive ring detail including a division in ring C. The SEB(N) is double. Delicate details exist in the SEB(S) and EZ.

Figure 10. 2003 Dec 13, 00:18UT, ω_1= 118°, ω_3= 057°, 279mm SCT, Phillips ToUcam Pro webcam at f/30, *J. R. Sanchez*. Bright white STropZ spot.

30–31 near λ_3= 243° and by Grafton (sharply) on Jan 14 near λ_3= 245°. Other such features were imaged by Grafton on Oct 19 (Figure 2) and by Peach on Oct 24 (barely), Oct 28 (easily), and Mar 1 (definite but tiny): the latter three were located at λ_3= 333, 330 and 326°: the first two are clearly identical, while the third could also be the same, but no white spots were associated with them.

Another transient dark bar was imaged by Peach on Jan 2 near λ_3= 150°. *Cassini* and the HST revealed further dark STropZ spots. Precise periods for WS1 and WS2 are:

Spot	*Limiting dates*	*No. obs.*	*Limiting longitudes*	*Δλ₃ (°/day)*
WS1c	Sep 13–Feb 20	18	200–254	+0.378
WS2c	Dec 12–Feb 16	13	091–106	+0.225
Average:				+0.302

STropZ average period: 10h 39m 36s

The average is marginally faster than 2002–'03.[10] Our final drift-rates differ slightly from the Interim Report[1] which had depended upon an incomplete dataset.

A thin and incomplete S. Tropical Belt (STropB) occasionally showed up on a few of the best images, which was at the very limit of visibility even upon the HST image of Mar 24. The STropZ spots lay just south of it.

South Equatorial Belt

Table 3 compares belt latitudes with the previous apparition. The only significant differences are at this latitude, being poleward shifts of the SEB(S) S. edge and the STropB.

The SEB was double, each component being broad, and the N. one much the darkest. The zone between them was well-marked and often light due to the white spot activity to be described below. The SEB(S) was itself double, though in January and February its southern part faded to near-invisibility at some longitudes, and the remaining N. component was less dark than the STB. The SEB(N) was sometimes observed to be double at some longitudes, or to have slightly darker edges.

Table 3. Saturnicentric latitudes, 2003–'04

Feature	*EG*	*DAP*	*2003–'04 Average*	*2002–'03 Average*
SSPCn	−88.6	−88.3	−88.4	−88.6
SSPBs	−77.4	−76.8	−77.1	−78.2
SSPBn	−73.4	−72.5	−73.0	−72.8
SPCn	−73.4	−72.5	−73.0	−72.8
SPRn	−63.5	−61.8	−62.6	−62.7
SPBs	−63.5	−61.8	−62.6	−62.7
SPBc	−61.8	−60.4	−61.1	−60.7
SPBn	−60.2	−58.9	−59.6	−58.8
SSSTBs	−55.5	−54.8	−55.2	−55.5
SSSTBn	−54.0	−52.2	−53.1	−53.5
SSTBs	−49.5	−49.6	−49.6	−49.1
SSTBn	−46.6	−46.8	−46.7	−46.6
STBs	−42.7	−42.4	−42.6	−42.4
STBc	−41.2	−40.8	−41.0	−40.9
STBn	−39.7	−39.2	−39.4	−39.5
STropBs	−36.6	−36.6	−36.6	−34.2
STropBn	−35.0	−35.0	−35.0	−32.1
SEB(S)s	−31.8	−31.9	−31.8	−29.3
SEB(S)n	−24.6	−25.3	−25.0	−25.3
SEB(N)s	−21.6	−22.0	−21.8	−22.1
SEB(N)n	−15.6	−15.8	−15.7	−15.8
EZ(S)Bs	−12.5	−12.0	−12.2	−12.7
EZ(S)Bn	−10.8	−9.8	−10.3	−11.1
EBs	−6.9	−7.4	−7.2	−7.4
EBc	−4.0	−4.4	−4.2	−4.7
EBn	−1.2	−1.4	−1.3	−2.0
EZ(N)Bs	+2.8	+2.6	+2.7	+2.8
EZ(N)Bn	+4.9	+4.2	+4.6	+5.1
Total	80	85	165	

Key to observers: EG, Grafton (the best 4 images); DAP, Peach (the best 6 images). All data were reduced by McKim.

Dark spots at the N. edge of the SEB(S) were apparent upon images from Nov 6 to Jan 14 (Figures 1–3, 8 and 9), and these were always just *p.* small, near-circular bright white spots in the SEBZ. Indeed there was a great increase in white spot activity within the SEBZ during the apparition, and the zone itself was relatively light. See Figure 6 for a drift-chart.

According to Sanchez–Lavega[9] the tracks of two of the SEBZ ovals could be extrapolated back to the two spots recorded by the HST on Aug 25. From our data it is also clear that the positions agree within a few degrees of the tracks of STropZ spots WS1 and WS2: we have charted these links but did not include other HST data in our drift-rate table or in the calculations given below. WS1 and WS4 were both recorded on the same image on Dec 7, and this was the final record of WS1. (Although there is quite a long interval between the final and penultimate records of WS1, the earlier observations extrapolate very accurately to its observed longitude on Dec 7). If WS1 survived beyond Dec 7 it may have coalesced with WS4.

On the IOPW website, Sanchez–Lavega[9] quoted a saturnigraphic latitude for the spots as −29.6° (−24.4° saturnicentric), and a mean drift rate of −7.5°/day for six features observed

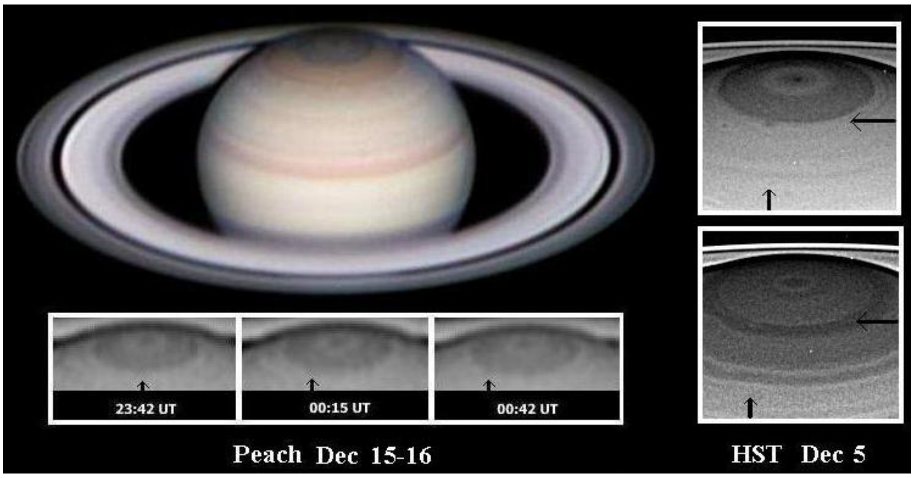

Figure 11. Showing SSSTeZ and SPCn/SSPBn spots. *Left:* 2003 Dec 15–16, 279mm SCT, ATK-1HS camera at f/31, *D. A. Peach*. Main image: Dec 16, 00:21UT, ω_1= 318°, ω_3= 331°. Tiny dark spot in the faded SEB(S) *f.* the CM. Note the SSPC. *Inset:* Enlarged red filter images at Dec 15, 23:42UT, Dec 16, 00:15UT and 00:42UT (ω_1= 295–330°, ω_3= 309–343°) to show the rotation of a tiny dark spot just N. of the SPC/SSPB. *Right:* 2003 Dec 5 HST images for comparison showing STropZ and (different) SPBn spots. *Top:* 675nm; *bottom:* 439nm

up to late December. We identified nine different spots in our data (with some small differences in identifications from him[9]) and have computed drift-rates for seven of them based entirely upon measurements from images, though Bowen and McKim also noticed the zone to be disturbed visually. Figure 6 shows that all drifts were highly uniform: our mean was −7.7°/day. The drift-rates for WS5 and (especially) WS6 are tentative due to few observations, but they agree well with the rest. The SEB(S) dark spots shared the same drift.

Spot	*Limiting dates*	*No. obs.*	*Limiting longitudes*	*Δλ₃ (°/day)*
WS1c	Sep 29–Dec 7	5	228–110	−6.92
WS2c	Oct 8–Oct 19	3	207–129	−7.48
WS3c	Oct 21–Nov 7	6	002–244	−6.89
WS4c	Nov 30–Dec 16	4	193–038	−9.84
WS5c	Dec 14–Jan 27	4	164–163	−8.00
WS6c	Dec 26–Jan 2	2	344–159	−10.25
WS7c	Jan 14–Feb 3	3	230–089	−7.13
Average (omitting WS6):				−7.71

SEBZ average period: 10h 33m 21s

Our SEBZ average period from 2002–'03 (for two white spots) was very similar: 10h 33m 10s.[10]

The SEB(N) had a number of dark projections and small festoons into the EZ(S). McKim found them better defined than in recent years. Gray saw a few such features, and Bowen (Figure 17) made the largest number of drawings and transits. These visual observers independently noticed the activity from 2003 December onwards (Gray from Dec 8 (Figure 9), Bowen from Dec 15 and McKim from Dec 17 (Figure 12)). Until January only a few short-lived features were detected.

Activity seemed to increase in February, growing to extend to around two-thirds of the planet's circumference. Accord was good: a dark spot seen by Gray on Dec 8 agreed in position with one imaged by Grafton on Dec 7, and on Mar 17 Bowen and McKim both located a dark spot at λ_1= 250°. The last record of activity was on Apr 8. Some strongly enhanced images also recorded spots (*e.g.*, Peach Jan 2, 27, Mar 1 and Grafton Dec 7, Jan 14, 20), but questions of objectivity arise, so that only visual data (measures off good drawings and CM transits) were plotted. All drifts were slightly positive:

Spot	*Limiting dates*	*No. obs.*	*Limiting longitudes*	*Δλ₃ (°/day)*
DS1c	Dec 8–Dec 17	2	102–113	+1.116
DS2c	Feb 19–Feb 29	5	179–184	+0.571
DS3c	Feb 19–Mar 23	11	194–244	+1.506
DS4c	Feb 29–Mar 17	5	234–250	+0.956
DS5c	Feb 29–Mar 23	6	249–264	+0.672
DS6c	Mar 6–Mar 20	3	285–285	+0.007
DS7c	Mar 6–Mar 20	2	310–316	+0.411
Average:				+0.748

SEB(N) average period: 10h 14m 33s

DS1 extrapolates roughly to DS3, but the gap in data suggests two different spots. DS2 persisted till at least Mar 13. DS5 and 6 probably existed as early as Feb 6.

In 2004 April, *Cassini* showed a wavy north edge to the SEB(N), confirming the ongoing activity at this latitude. Bowen considered that some sections of the SEB N. component were closely double, and the best images of Grafton and Peach support this contention.

Equatorial Zone

The southern part of the EZ, strongly yellow, was rather dull. The EZ(N) was less yellow and of similar intensity this time. The EB was broad, fairly dark, and easy to see. The EZ(S)B and EZ(N)B on either side were inconspicuous, with the former visible in only a handful of images, but Biver on Apr 12 and Gray on Dec 8 (Figure 9) caught

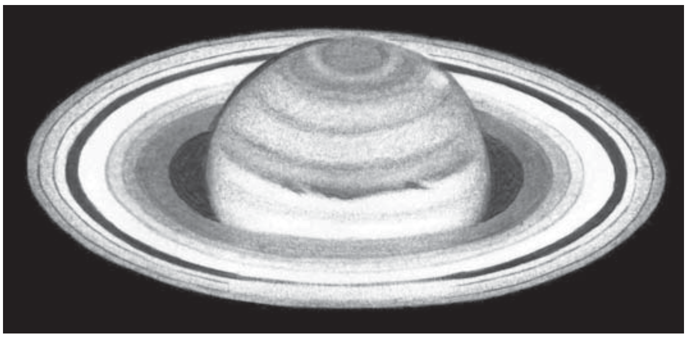

Figure 12. 2003 Dec 17, 20:50UT, ω_1= 083°, ω_3= 034°, 410mm DK Cass., ×410, drawn by *R. J. McKim*. Fine ring details. The SSSTB is seen just N. of the SPB. Light patch in STeZ on *f.* side, and several details in SEB(N).

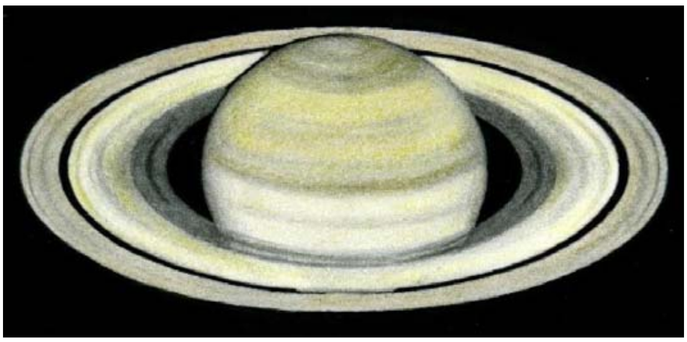

Figure 13. 2003 Dec 23, 00:10UT, ω_1= 102°, ω_3= 241°, 407mm refl., ×461, drawn by *N. D. Biver*. Many fine ring details including the division in ring C. The light area within the SPC is seen, and there is a greenish tint south of the STB.

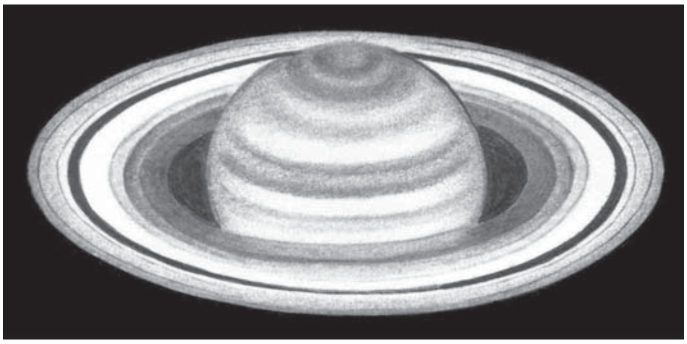

Figure 14. 2004 Jan 8, 21:00UT, ω_1= 306°, ω_3= 240°, 410mm DK Cass., ×265, ×410, drawn by *R. J. McKim*. Fine ring details. Light patch at centre of SPC; SSPB, SPB, SSSTB and STB are all noted along with the EB and EZ(N)B.

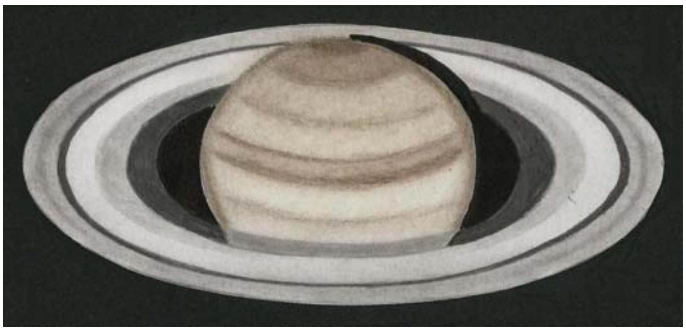

Figure 16. 2004 Feb 29, 21:00UT, ω_1= 290°, ω_3= 282°, 152mm MKT, ×200, drawn by *D. L. Graham*. Encke complex; thin STB.

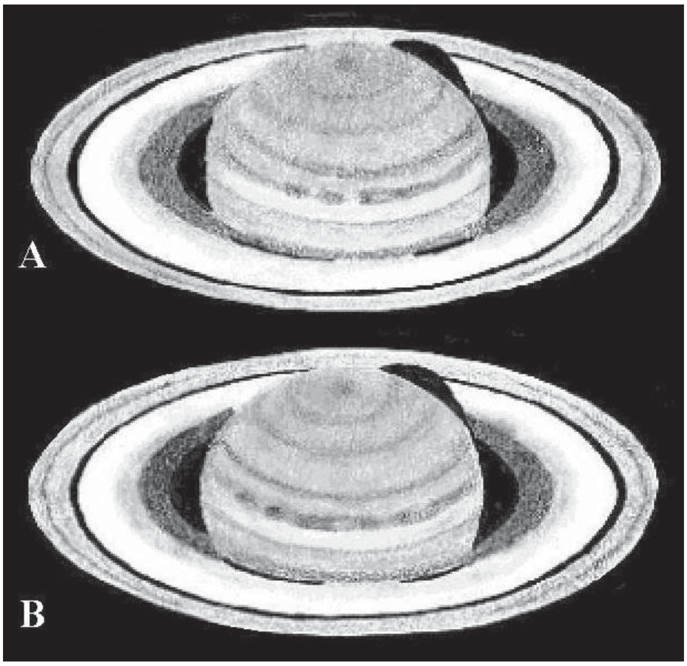

Figure 17. 2004 Mar 17, showing the rotation of dark spots (and a short double section) in the SEB(N) from 21:00UT (A) to 22:00UT (B), ω_1= 242–277°, ω_3= 024–057°, 300mm refl., ×300, drawn by *R. D. Bowen*. Note also the SSPC, SPB, STB and EB, the form of ShGR, and the partial visibility of ShRG at the N. limit of ring C crossing the globe.

both visually, and McKim saw the EZ(N)B on Jan 8 (Figure 14). Bowen on Mar 1 saw a dark condensation upon the EB.

There was very little activity, but the zone and the belts within it sometimes were uneven in tone in some of the sharpest images and on a few occasions actual very inconspicuous white spots were detected in the EZ(S) between Nov 28 and Jan 23. Gray shows a small lighter patch in the EZ(S) on Dec 8 (Figure 9), for instance, and the most obvious one was imaged by Sanchez on Jan 23, although this, like a few others, was only visible upon one date. *Cassini* recorded equatorial disturbances at longer wavebands, particularly in methane band images, for example during 2004 Feb 15–19.[7] Sanchez–Lavega[9] obtained evidence from HST data that the EZ drift-rate remained considerably slower than System I. Our own results support the continuing slow drift, in perfect accord with our EZ data since 1994–'95:

Spot	*Limiting dates*	*No. obs.*	*Limiting longitudes*	*$\Delta\lambda_3$ (°/day)*
WS1c	Nov 28–Dec 16	4	192–341	+8.295
WS2c	Dec 02–14	3	105–235	+11.195
Average:				+9.745

EZ(S) average period: 10h 16m 10s

Northern hemisphere

From Earth no part of the N. hemisphere was visible north of the rings crossing the globe, but part of the NTeZ was illuminated by sunlight passing through the Cassini Division, as in 2002–'03. The vantage point of *Cassini* (Figure 4) revealed the NTeZ to have a beautiful blue colour, in contrast to the yellow cast of the southern globe. (*Cassini* would obtain even better images of this difference in 2004–'05.) This seasonal colour difference is well-established.

Partial confirmation comes from several observations showing the north globe through the Cassini Division (Figures 7, 10, 11, 13 and 15): the N. globe (NTeZ) is brightest in blue (Figure 7) or ultraviolet (Figure 15) light.

The rings

Nomenclature for the rings is given in Figure 2. Ring A showed its usual blue-grey tone (Foulkes, McKim). The minor divisions of rings A, B and C were again well observed during 2003–'04: full descriptive details are not repeated here. Sheehan using the Lick refractor on Sep 12 easily saw these minor divisions as well as the one between rings B and C, but no ring spokes.[1]

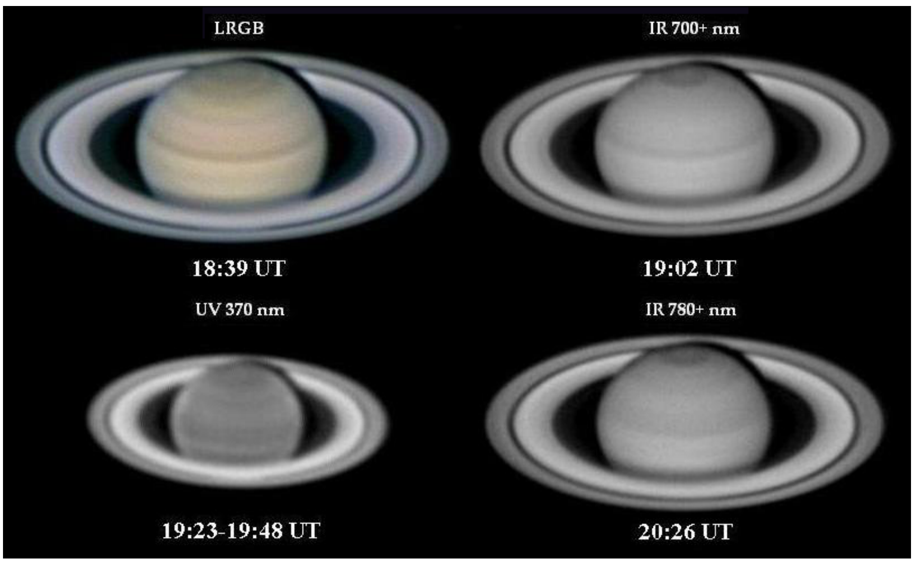

Figure 15. 2004 Feb 9, 18:39–20:26UT, ω_1= 242–269°, ω_3= 251–278°, 356mm SCT, images with ATK-1HS camera, *C. E. Pellier*.

In very good seeing Ring C looked 'dark chocolate' to Heath, Mar 1, but it appeared dark grey on Mar 17: most observers simply called it grey. A warm brown tone was habitually recorded by Gray with a large aperture so essential to detect the true colour in this ring. Gray again compared the brightness of ring C at the ansae in white light and found the *p.* side up to one intensity scale point brighter in 27 records, and the *f.* brighter on 11 occasions; on only two dates were they identical. Heath too found a difference on one night: on Mar 17, ring C looked brighter on the *f.* side.

Ring C crossing the globe (C_m) again looked unusually light to Gray; the average intensity derived by the Section (Table 2) was lower than in 2002–'03. ShGR was of course well seen, and Figure 4 shows how its visibility varied with vantage point. ShRG was harder to see, visible only at the N. edge of C_m, but it was recorded visually by Bowen, Gray and McKim during parts of the apparition.

There were fewer systematic reports of the bicoloured aspect of the rings in 2003–'04, as only Calia and Gray looked for it. Calia used a W23A red filter and a W80A blue filter, and found the ansae equal in red, blue and integrated light on Feb 20, 23, 28, Mar 22 with a suspected difference in red and blue on Feb 24. Gray used W25 red and W38A blue filters. On Nov 25 the *f.* ansa of ring A1 was brighter in red, but the *p.* ansa of ring C was brighter in red. On Dec 7 the *f.* ansae of ring A1 and ring C were brighter in blue, while their *p.* ansae were brighter in red. On Dec 8 both A1 and C were equal in red, but their *p.* ansae looked brighter in blue. Some other positive sightings were logged by the ALPO.[3]

Heath recorded the contrast effect of the Terby White Spot *p.* the ShGR on Nov 15 and Dec 11, and it was apparent on both sides of the globe on Mar 17.

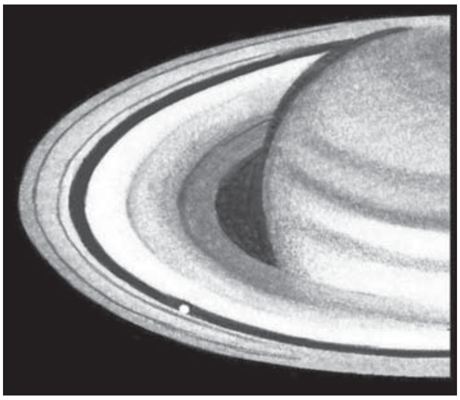

Figure 18A. The occultation of SAO 78867 on 2003 Nov 15 observed visually. Disk drawing timed at 06:00UT, ω_1= 260°, ω_3= 224°, 410mm DK Cass., ×265, ×410, *R. J. McKim*. The star however is shown inside the Cassini Division for 05:51–52UT.

Satellites

Calia observed Titan using an Optec SSP-3 photoelectric photometer (with ι Geminorum as comparison star), obtaining altitude-corrected magnitudes of 8.45 on Mar 21 and 8.24 on Mar 28. (The *Handbook* gives its mean visual opposition magnitude as 8.3.)

Several observers submitted images of (or recorded visually) the inner satellites Mimas and Enceladus. Foulkes and Meredith also imaged Hyperion.

Occultation of the star SAO 78867

The occultation of a bright star by Saturn's rings is a rare event. Alexander[12] usefully reviews instances up to 1962. We can add the striking case of 5th magnitude 28 Sgr on 1989 Jul 3, which was occulted both by the rings and Titan.[13–15]

The 8.6 magnitude star SAO 78867 was predicted to be occulted by Titan on the night of 2003 Nov 13/14,[16] though only an appulse was expected from the UK. We did not receive reports of anyone having observed this event, which was predicted for 00.11UT. At the writer's observatory the sky was totally overcast, but he waited until midnight in the hope of it clearing. Observers had greater fortune the following night, when the same star was occulted by the rings and globe of Saturn.

Predicted timings[16] of the different phases of the occultation for the morning of Nov 15 proved useful, and positive visual observations were made by Heath and McKim in the UK, while

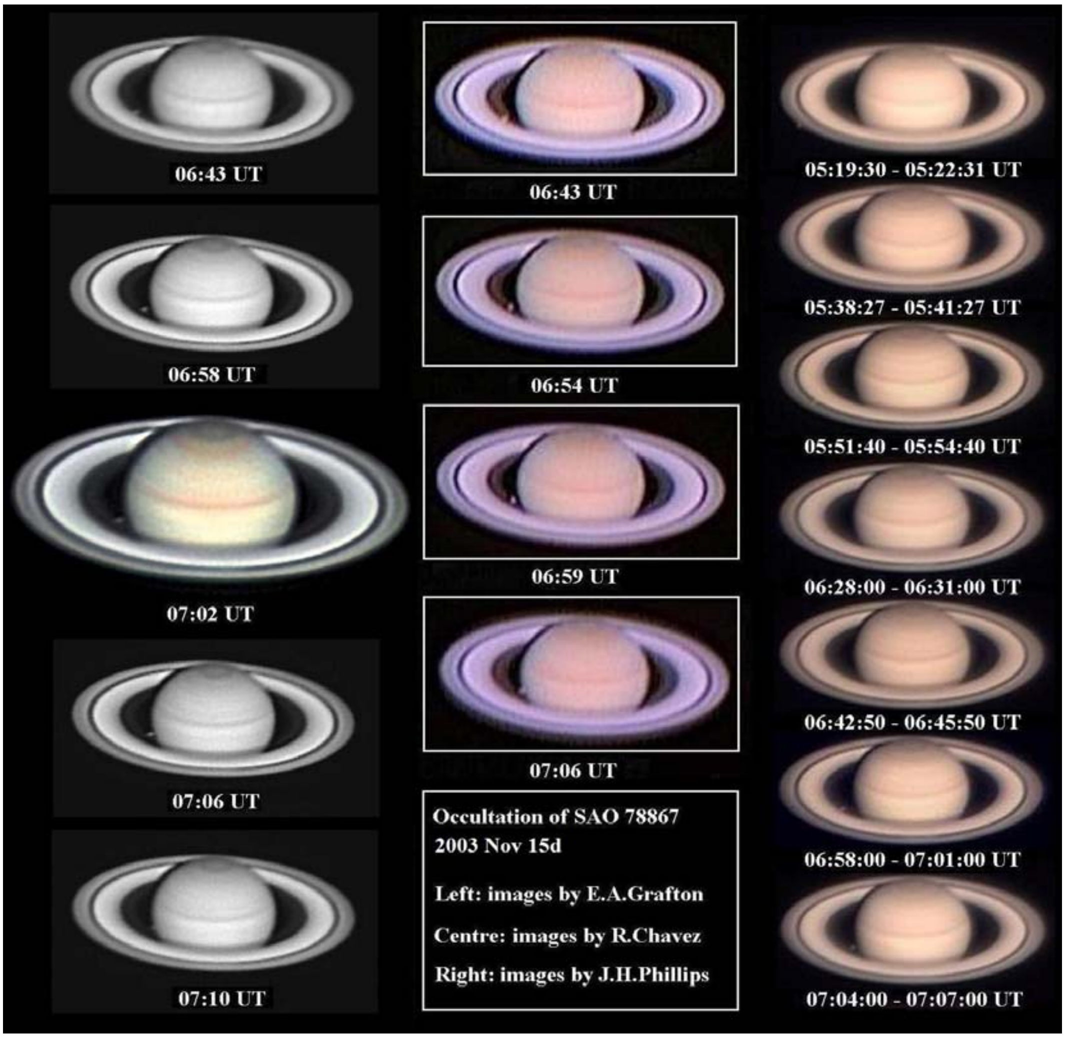

Figure 18B. The occultation of SAO 78867 on 2003 Nov 15 observed by imaging. *Left:* 356mm SCT, ST5C CCD camera at f/27, *E. A. Grafton*. *Centre:* 203mm refl., Philips ToUcam webcam, *R. Chavez*. *Right:* 229mm OG, Philips ToUcam webcam at f/30, *J. H. Phillips*.

Chavez, Grafton and Phillips (all observing from the USA) secured excellent images. The USA observers were favoured, for in the UK the event occurred shortly before dawn.[1]

Heath saw the star close to the outer edge of ring A at 05:10 UT, with contact at 05:20 UT. The star then disappeared. Heath saw it again at 05:37 UT when its position must have been in the Encke Gap. Cloud prevented Heath from seeing the star in the Cassini Division, but he saw it again at about 05:50 UT. At that time he reported its being just within the outer edge of ring B. Uncertain glimpses continued, but twilight was now interfering badly and observation soon had to be given up.

McKim attempted to observe the event, but had cloud interference early on. Upon opening up at 05:15 UT, the seeing was much too poor to see the star. Missing the immersion he had good seeing at 05:30 UT, when the star was invisible within ring A. However he was definitely able to see the star near the inner edge of the Cassini Division during clear intervals, from 05:51 to 05:52 UT (Figure 18A). It then disappeared into ring B, although conditions were good enough to see Enceladus. By 06:10 UT, with the star still inside ring B and having not reappeared at any point, the sky had become too light to continue.

Grafton also had considerable cloud interference in Texas, but imaged the star within the outer edge of ring C at 06:43 UT. The image sequence (Figure 18B) shows that the star was continuously visible, and that it neared the inner edge of ring C by 06:58 UT, being very close to it at 07:02 UT. At 07:06 UT the star was in the gap between ring C and the globe, and at 07:10 UT it was touching the planet's limb.

Chavez also first caught the star just within ring C at 06:43 UT. At 06:59 UT it appeared to have reached the inner edge. At 07:06 UT it was approaching Saturn's limb: see Figure 18B.

Philips secured the best set of results, the following times being the integration times for the images illustrated in Figure 18B and do not represent nearest-second timings of events.

05:19:30–05:22:31 UT	Embedded in the outer edge of ring A
05:38:27–05:41:27 UT	Brightening midway in ring A
05:51:40–05:54:40 UT	In the Cassini Division
06:28:00–06:31:00 UT	At the inner edge of ring B
06:42:50–06:45:50 UT	At the outer edge of ring C
06:58:00–07:01:00 UT	At the inner edge of ring C
07:04:00–07:07:00 UT	In the W. ansa

The star was hardly dimmed by ring C but faded somewhat during its passage through ring A. The star was not seen at all through ring B, except very faintly at the inner edge: an animation can be watched online.[4,5]

It can be seen that the observed timings, allowing for the parallax arising from observer location,[16] agree very well.

The star later emerged from occultation by the globe to undergo a further series of ring events. We did not receive observations of these, but the ALPO report[3] prints an image obtained by T. Williamson (USA) after the star had emerged from occultation by the globe. Another less favourable occultation of the star SAO 78832 predicted for Nov 25 apparently went unobserved.

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Addendum: Saturn, 2002–'03

In the Appendix to the last report,[10] I referred to a bright spot observed in 1683 whose location was not recorded in the literature. S. Lecomte has very kindly informed me that the original observations by Cassini for 1683 Mar 2 reveal a brightening of the EZ(S), but with no discrete spot resolved. (The zone was much less bright earlier or later.) I am further informed that the first mention of the observation was in *Histoire de l'Académie Royale des sciences* – Depuis son établissement en 1666 jusqu'à 1686, (1733) pp 376–378.

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2 Images of this event secured by J. H. Phillips were previously published: *ibid*., **114**(1), 39 (2004)
3 J. L. Benton, *J. Assoc. Lunar Planet. Obs*., **49**(2), 32–55 (2007)
4 The IOPW website: **http://www.pvol.ehu.es**
5 The ALPO JAPAN website (which became fully international at this opposition): **http://alpo-j.asahikawa-med.ac.jp/Latest/Saturn.htm**
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16 Useful predictions were published in A. Ling, *Astronomy*, 2003 Nov, pp 76–77. These show that parallax caused the predicted ring A immersion times to range from 05:20 UT (London) to 05:30 UT (Honolulu). Passage through the Cassini Division was expected to last 3–4 minutes.

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